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H04N 5/21

(52) UK CL (Edition P)
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INT CL^6 **H04N 5/00 5/14 5/21 5/213**
Online:WPI

(54) Abstract Title
Filtering method for reducing blocking effect and ringing noise of image data

(57) A gradient of image data is calculated for each pixel of the image data (410) and is compared with a global threshold value (T_g) which is determined based on a predetermined quantization step (420). The gradient data of each pixel is compared with a local threshold value (T_n) which is determined for each block having a predetermined size, (430). An OR operation is performed (440) with respect to the global edge map information and the local edge map information to generate binary edge map information (450). A filter window of a predetermined size is applied to determine whether edges are present (460). The pixel values of the corresponding filter window are filtered pixel by pixel by using predetermined first weighted values to generate a new pixel value if it is determined that edges are not present (485). The pixel values of the corresponding filter window are filtered pixel by pixel by using predetermined second weighted values to generate a new pixel value if it is determined that edges are present (480), while the filtering is not performed if the pixel located at the center of the filter window represents an edge (475).

FIG. 4

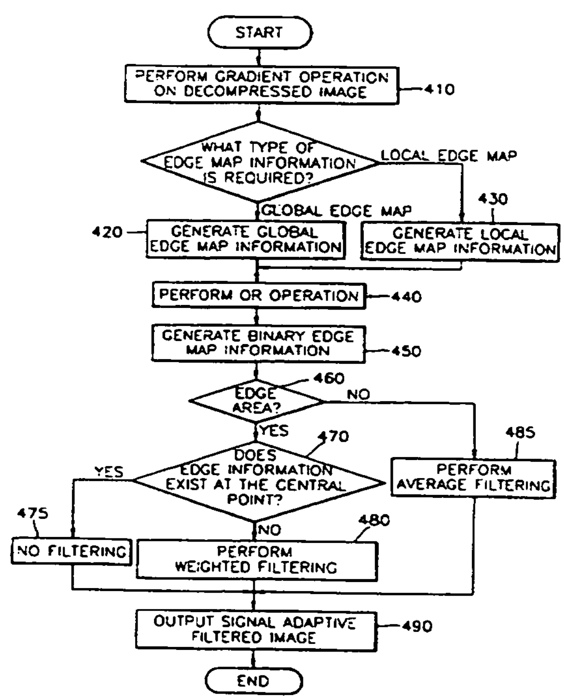

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FIG. 1

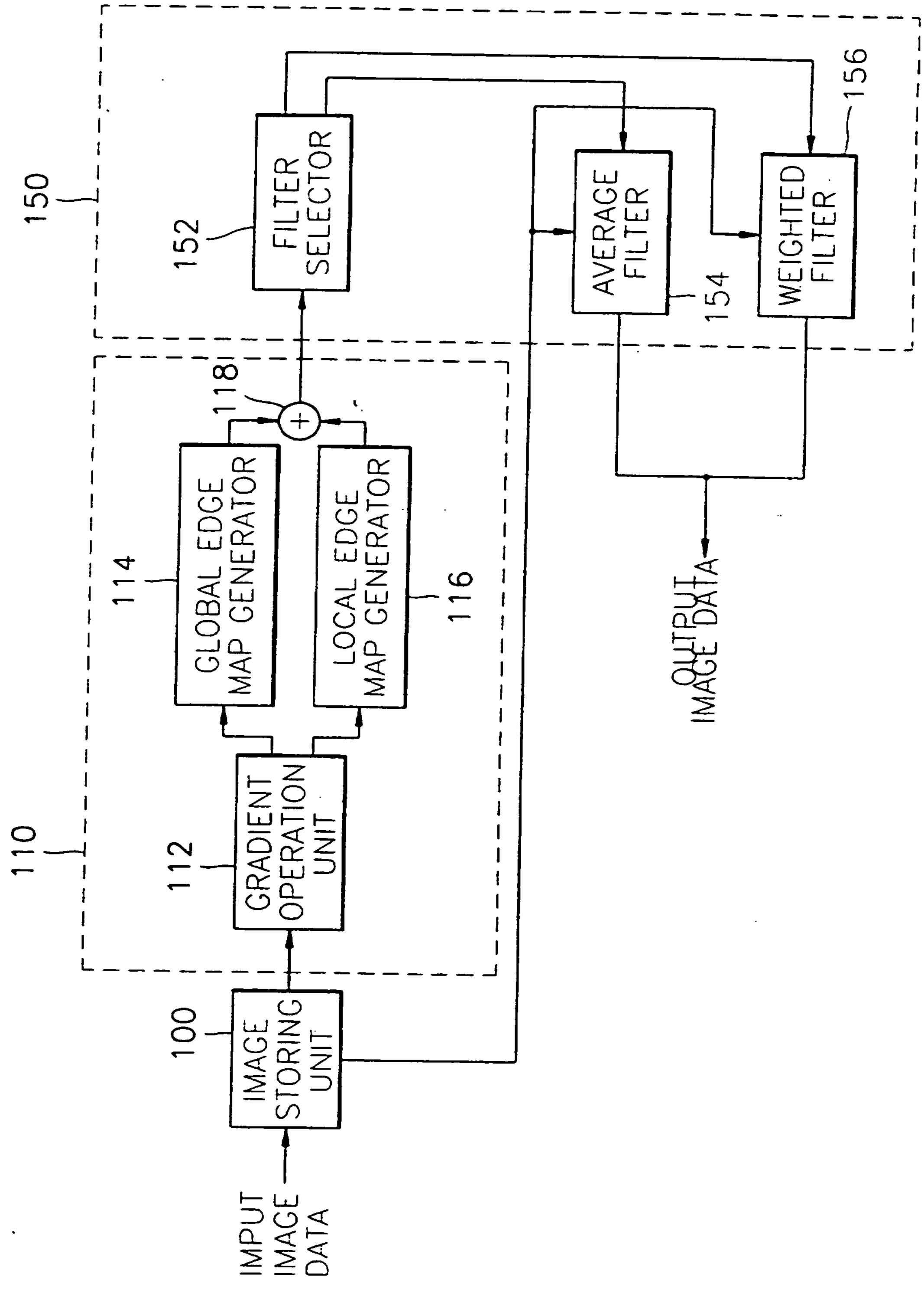

IMPUT IMAGE DATA
IMAGE STORING UNIT
100
110
112
GRADIENT OPERATION UNIT
114
GLOBAL EDGE MAP GENERATOR
116
LOCAL EDGE MAP GENERATOR
118
150
152
FILTER SELECTOR
AVERAGE FILTER
154
WEIGHTED FILTER
156
OUTPUT IMAGE DATA

FIG. 2

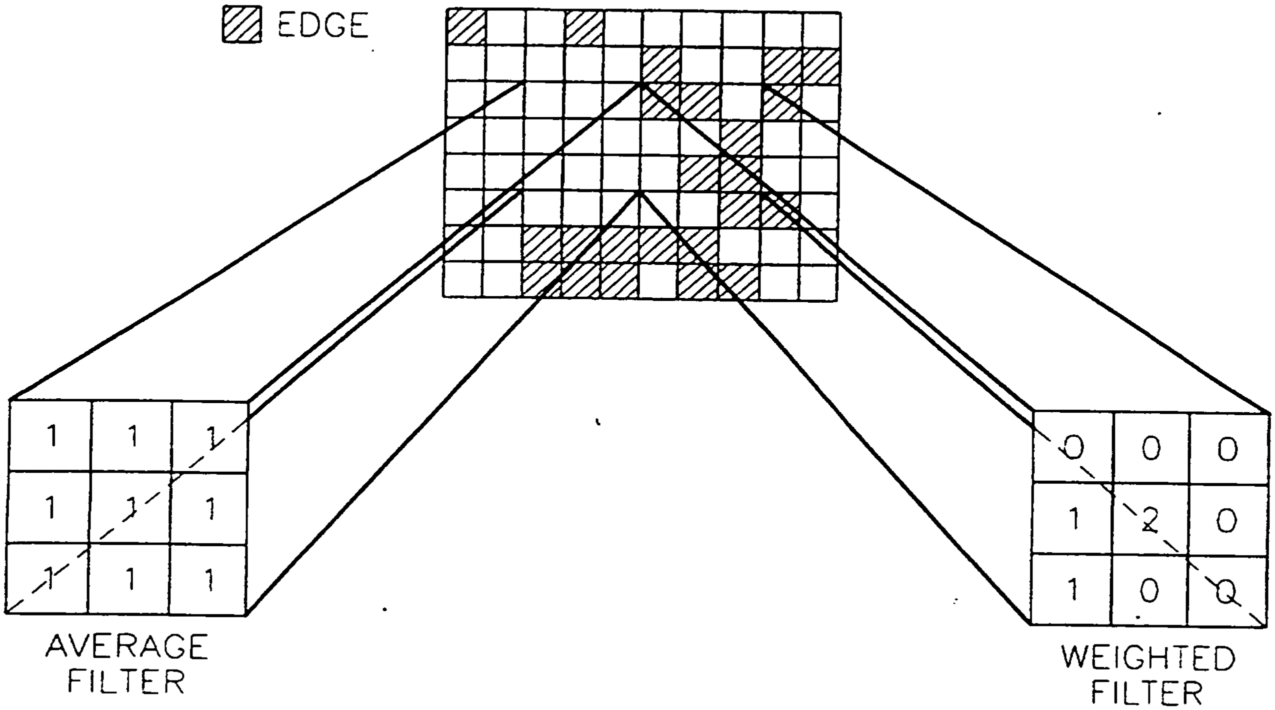


FIG. 3A

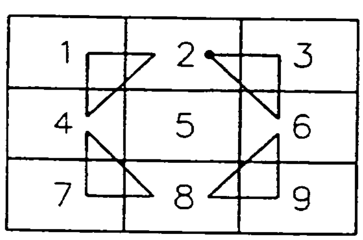


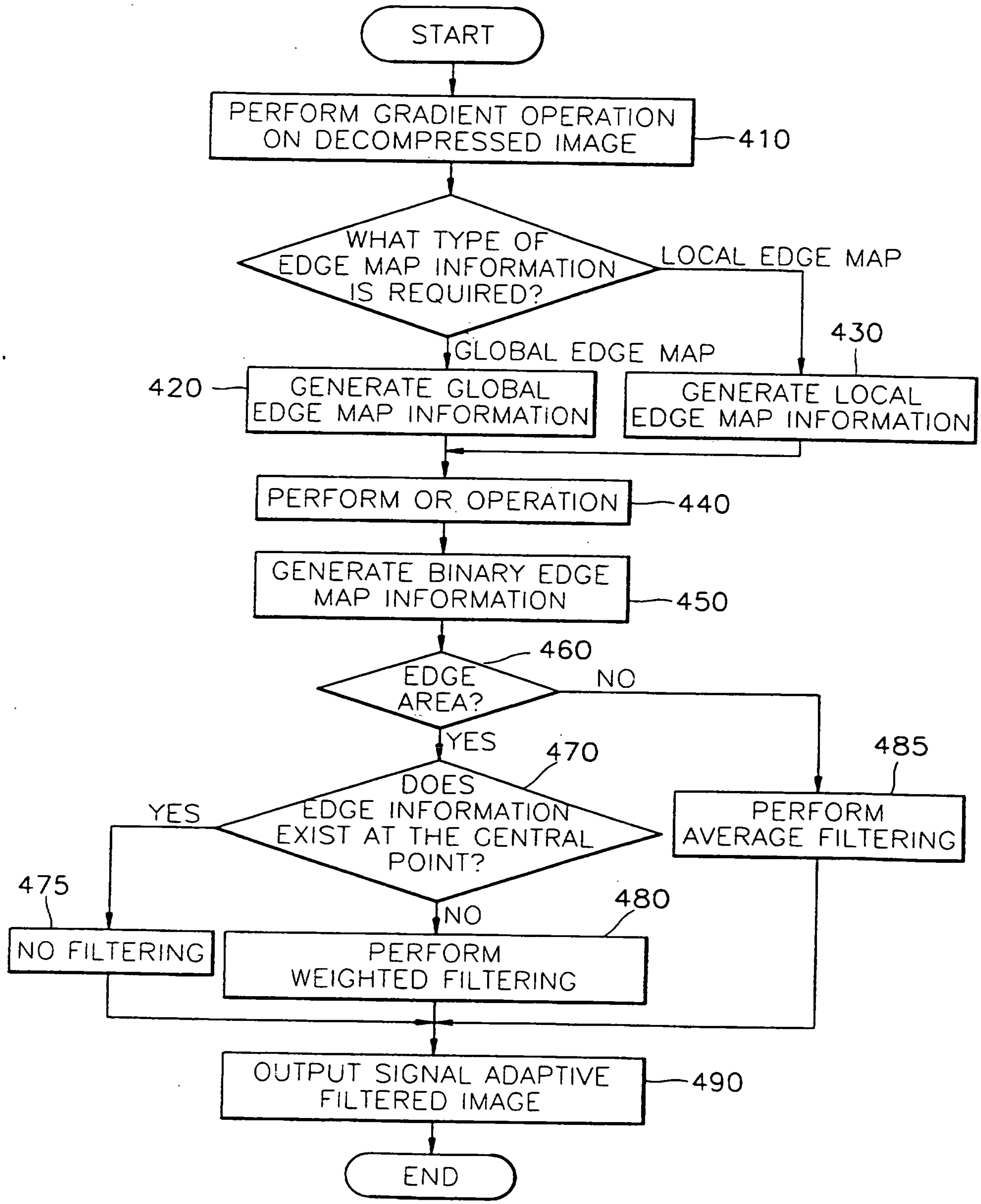
FIG. 3B

1	1	1
1	1	1
1	1	1

FIG. 3C

1	1	1
1	2	1
1	1	1

FIG. 4


START
PERFORM GRADIENT OPERATION ON DECOMPRESSED IMAGE
410
WHAT TYPE OF EDGE MAP INFORMATION IS REQUIRED?
LOCAL EDGE MAP
GLOBAL EDGE MAP
420
GENERATE GLOBAL EDGE MAP INFORMATION
430
GENERATE LOCAL EDGE MAP INFORMATION
PERFORM OR OPERATION
440
GENERATE BINARY EDGE MAP INFORMATION
450
460
EDGE AREA?
NO
YES
470
DOES EDGE INFORMATION EXIST AT THE CENTRAL POINT?
YES
NO
485
PERFORM AVERAGE FILTERING
475
NO FILTERING
480
PERFORM WEIGHTED FILTERING
OUTPUT SIGNAL ADAPTIVE FILTERED IMAGE
490
END

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SIGNAL ADAPTIVE FILTERING METHOD AND SIGNAL ADAPTIVE FILTER

The present invention relates generally to the field of data filtering. More particularly, preferred embodiments of the invention relate to a signal adaptive filtering method for reducing a blocking effect and ringing noise, and a signal adaptive filter suitable for the method.

Generally, picture encoding standards such as MPEG of the International Organization for Standardization (ISO) and H.263 recommended by the International Telecommunication Union (ITU) adopt block-based motion estimation and discrete cosine transform (DCT) of blocks. When an image is highly compressed, the block-based coding may cause a blocking effect and ringing noise, as is well known. A typical blocking effect is grid noise in a homogeneous area in which adjacent pixels have relatively similar pixel values. Another blocking effect is staircase noise which has the shape of a staircase and is generated along the edge of the image. Also, the ringing noise is due to the typical Gibb's phenomenon which results from the truncation of a DCT coefficient by quantization when the image is highly compressed.

In the case of grid noise, traces caused by the process performed on each block may be shown at the boundary between blocks when the compressed data is restored to be displayed on a screen, so that the border between blocks can be noticed by a user. In the case of staircase noise, the edge of the image has the shape of a staircase, so that the jagged edge of the image is noticed by a user. The ringing noise causes a problem in that an

object in the image is displayed as multiple overlapping objects.

An aim of preferred embodiments of the present invention is to provide a signal adaptive filtering method for reducing the blocking effect and ringing noise in a high compression encoding system and a signal adaptive filter for implementing the method.

In a signal adaptive filtering method according to the present invention, a gradient of the image data is calculated for each pixel of the image data. Then, the gradient data of each pixel is compared with a global threshold value (T_g) which is determined based on a predetermined quantization step (Q), and a global edge map information of the pixel is generated. Meanwhile, the gradient data of each pixel is compared with a local threshold value (T_n) which is determined for each block having a predetermined size, and a local edge map information of the pixel is generated. An OR operation is performed with respect to the global edge map information and the local edge map information to generate binary edge map information. Then, a filter window of a predetermined size is applied to determine whether edges are present in the filter window based on the binary edge map information within the filter window. Afterwards, the pixel values of the corresponding filter window are filtered pixel by pixel by using predetermined first weighted values to generate a new pixel value if it is determined that edges are not present. Also, the pixel values of the corresponding filter window are filtered pixel by pixel by using predetermined second weighted values to generate a new pixel value if it is determined that edges are present, while, the filtering is not performed if the

pixel located at the center of the filter window represents an edge.

Preferably, the global threshold value (Tg) is determined by:

$$T_g = \begin{cases} 4Q+60, & 6 \le Q \le 18 \\ 84, & Q \le 5 \\ 132, & Q \ge 19. \end{cases}$$

where Q is the quantization step of a quantizer.

Meanwhile, a signal adaptive filter of the present invention comprises an image storing unit for temporarily storing decompressed image data; a gradient operation unit for receiving the image data from the image storing unit in block units of a predetermined size and calculating a gradient of the image data in the horizontal and vertical directions by using gradient operators to find edge pixels; a global edge map generator for comparing the gradient data of each pixel output by the gradient operation unit with a global threshold value (T_g) determined based on a quantization step (Q) to generate binary global edge map information; a local edge map generator for comparing the gradient data pixel by pixel, output by the gradient operation unit, with a local threshold value which is individually determined for each block of a predetermined size, to generate binary local edge map information; an OR-gate for OR-operating, pixel by pixel, the global edge map information from the global edge map generator and the local edge map information from the local edge map generator to generate binary edge map

information; a filter selector for storing the binary edge map information output by the OR-gate and classifying the input image data into an edge area including information of at least one edge and a homogeneous areas without information of any edges, according to the binary edge map information; an average filter for performing an average filtering on a central pixel within a filtering window of a filtering area, the filtering area being classified as a homogeneous area by the filter selector, to generate a new pixel value; and a weighted filter for performing a weighted filtering on the central pixel within a filtering window of a filtering area, the filtering area being classified as an edge area by the filter selector, to generate a new pixel value.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a block diagram of a preferred embodiment of a signal adaptive filter according to the present invention;

Figure 2 illustrates a binary edge map generated by a binary edge map information generator, and low pass filters used in a signal adaptive filtering unit;

Figure 3A illustrates a filtering window for a 2-dimensional 3×3 filter;

Figures 3B and 3C are diagrams showing weights for the 2-dimensional 3×3 filter; and

Figure 4 is a flowchart illustrating a signal adaptive filtering method according to the present invention.

In Figure 1, a signal adaptive filter includes an image storing unit 100, a binary edge map information generator 110 and a filtering unit 150. Figure 4 is a flowchart illustrating a signal adaptive filtering method of the present invention.

The image storing unit 100 temporarily stores image data which passed through an inverse discrete cosine transform (inverse-DCT) and decompression and includes blocking effect and ringing noise.

The binary edge map information generator 110 generates binary edge information including a global edge and a local edge of the decompressed image stored in the image storing unit 100. The binary edge map information generator 110 includes a gradient operation unit 112, a global edge map generator 114 and a local edge map generator 116.

The filtering unit 150 includes an average filter 154 and a weighted filter 156. The filtering unit 150 selects the average filter 154 or the weight filter 156 based on the generated binary edge map information, and filters the decompressed image data by using the selected filter to decrease grid noise and staircase noise.

The gradient operation unit 112 calculates a gradient of the image data from the image storing unit 100 in pixel units by use of a gradient operator in order to find edge pixels (step 410). Preferably, the gradient operator includes a vertical sobel gradient operator (∇_v) and a

horizontal sobel gradient operator (∇_h). The gradient data is provided to the global edge map generator 114 and the local edge map generator 116.

The global edge map generator 114 receives the gradient data from the gradient operation unit 112 to generate global edge map information for each frame (step 420). The global edge map information **edge(i,j)** is obtained by calculating an absolute gradient sum for each pixel and then comparing the absolute gradient sum with a global threshold value $\mathbf{T_g}$, as described in the following equation (1).

$$\text{edge}(i,j) = \begin{cases} 1, & \text{if } |\nabla_h(i,j)| + |\nabla_v(i,j)| \geq T_g \\ 0, & \text{if } |\nabla_h(i,j)| + |\nabla_v(i,j)| < T_g \end{cases}$$

Here, the global threshold value $\mathbf{T_g}$ is determined according to a quantization steps **Q** of a quantizer. In case that each pixel may have one of 256 gray levels, the global threshold value $\mathbf{T_g}$ is determined by the following equation (2).

$$T_g = \begin{cases} 4Q+60, & 6 \leq Q \leq 18 \\ 84, & Q \leq 5 \\ 132, & Q \geq 19 \end{cases} \quad \cdots (2)$$

Here, the value of quantization step **Q** is determined according to the bandwidth of a channel of the image data. That is, if the bandwidth is larger, the **Q** value is set to be a smaller value because there is more data to be transmitted.

Thus, the global edge map generator 114 determines the global edge map information **edge(i,j)** of the pixel to

be "1" if the absolute gradient sum calculated for the pixel is greater than or equal to the global threshold value $\mathbf{T_g}$. On the contrary, the global edge map generator 114 determines the global edge map information **edge(i,j)** of the pixel to be "0" if the absolute gradient sum calculated for the pixel is less than the global threshold value $\mathbf{T_g}$. The global edge map information obtained by the above step to each frame is provided to an OR-gate 118.

The local edge map generator 116 receives the gradient data output by the gradient operation unit 112 to generate a local edge map. That is, the local edge map generator 116 calculates a local threshold value with respect to each $M_1 \times M_2$ block of the gradient data and generates the local edge map information with respect to all the pixels within the corresponding block by use of the calculated local threshold value (step 430). According to the MPEG standard, a block-based signal process such as DCT and quantization is basically performed on 8×8 blocks each including 8×8 pixels. Thus, in the present embodiment, the local edge map generator 116 receives the gradient data values in macroblock units of 16×16 size each including 16×16 pixels, and generates the local edge map information in a unit of 8×8 block. However, it is noted that the sizes of the macroblock and block are not limited to the above embodiment.

A local threshold value $\mathbf{T_n}$ of the n-th 8×8 gradient data block is calculated by:

$$T_n = \left| 1 - \frac{\sigma_n}{m_n} \right| * T_g$$

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$$\sigma_n = \sqrt{\frac{1}{N} \sum_{(i,j) \in R_n} \{g(i,j) - m_n\}^2}$$

$$m_n = \frac{1}{N} \sum_{(i,j) \in R_n} g(i,j)$$

Here, g(i,j) represents a gradient image or a gradient data, R_n represents the n-th 8×8 block region, m_n and σ_n denote the average and standard deviation, respectively, of the n-th 8×8 block, and $\mathbf{T}_g$ denotes a global threshold value.

Thus, $\mathbf{T}_n$ is used to generate a detailed edge map information, that is, local edge map information which is not classified as global edges by $\mathbf{T}_g$. If the n-th 8×8 block is homogeneous, the ratio of σ_n/m_n tends to be "0", so that $\mathbf{T}_n$ is nearly equal to $\mathbf{T}_g$. On the contrary, if the n-th block of 8×8 size block is a part of a complicate image, the ratio of σ_n/m_n increases so that $\mathbf{T}_n$ becomes less than $\mathbf{T}_g$.

The local edge map generator 116 compares the local threshold value $\mathbf{T}_n$ of the n-th 8×8 block with some of the gradient data of the block individually. Here, some of the gradient data corresponds to 6×6 pixels of an 8×8 size block, excluding the boundary pixels. If the gradient data used for generating the local edge map are defined as the above, detailed information is protected from being blurred, and the grid noise is prevented from being detected as an image edge. If the gradient data which is allowed within the n-th 8×8 size block is greater than or equal to the local threshold value $\mathbf{T}_n$, the local edge map

generator 116 determines the local edge information corresponding to the block to be "1". On the contrary, the local edge map generator 116 determines the local edge value to be "0" if the gradient value is less than T_D. The local edge map information obtained from the above step is provided to the OR-gate 118.

The OR-gate 118 performs an OR operation on the global edge map information generated by the global edge map generator 114 and the local edge map information generated by the local edge map generator 116 (step 440). In detail, the OR-gate 118 performs the OR operation on the global edge value and the local edge value of each pixel. The OR-gate 118 performs the OR operation with respect to all the global edge values of the global edge map and all the local edge values of the local edge map, to generate binary edge map information (step 450). The OR-gate 118 then outputs the result to a filter selector 152. Figure 2 shows a binary edge map generated by the binary edge map information generator 110 and low-pass filters used in the filtering unit 150.

The filter selector 152 stores the binary edge map information provided by the OR-gate 118, and classifies the decompressed input image data into edge areas and homogeneous areas according to the binary edge map information from the binary edge map information generator 110.

The average filter 154 and the weighted filter 156 use a filter window of 3×3 size in the present embodiment. Thus, the filter window used in the filter selector 152 is also of 3×3 size. The filter selector 152 determines whether a part of the binary edge map in which the filter window is located belongs to an edge area or a homogeneous

area based on the edge information within the filter window (step 460). In more detail, the filter selector 152 sets a filtering area of the image data of 3×3 size for each pixel by use of the filtering window of 3×3 size. Then, it is checked whether any pixel within the filtering area represents edge information. A filtering area having a pixel representing the edge information is referred to as an "edge area", and a filtering area without the edge information is referred to as a "homogeneous area".

If the filtering area is determined to be an edge area, the filter selector 152 outputs the binary edge map information of the filter window used for the decision and position data of the central pixel in the filter window to the weighted filter 156. Also, the filter selector 152 checks whether the central pixel in the filter represents edge information based on the position data of the central pixel in the filter window (step 470). If the central pixel represents edge information, the pixel value of the original input image data is used as it is without being filtered (step 475). However, if the central pixel does not represent edge information, a weighted filtering is performed for the input image data (step 475). Thus, the pixel value of the central pixel in the filter window is replaced by a new value.

If the filtering area is determined to the homogeneous area, the filter selector 152 outputs the position data of the central pixel in the filter window used for the decision, so that the average filter 154 performs an average filtering (step 485).

Figures 3A, 3B and 3C relate to a two-dimensional 3×3 filter. In detail, Figure 3A shows a filter window for a 3×3 filter, Figure 3B shows weights for a 3×3 average

filter, and Figure 3C shows weights for a 3×3 weighted filter, respectively. In the filter window shown in Figure 3A, the pixel having an index of "5" represents the central pixel in the filter window.

The average filter 154 and the weighted filter 156, which are two-dimensional low pass filters, will now be described in detail.

When the position data of the central pixel is input, the average filter 154 reads the pixel values required for calculating the filtered pixel value of the central pixel from the image storing unit 100. Then, the average filter 154 calculates the filtered pixel value by use of the read pixel values and the weights shown in Figure 3B. The calculated filtered pixel value is used as a new pixel value for the central pixel.

The weighted filter 156 performs the filtering operation based on the binary edge map information provided from the filter selector 152 and the position data of the central pixel. The operation of the weighted filter 156 will be described through the following example, for a clearer understanding. If the central pixel of index "5" is on an edge, the weighted filter 156 does not perform the filtering operation on the central pixel. If an edge point (or edge points) exists within the 3×3 filter window, but not at the central pixel, the weighted filter 156 performs the filtering operation using the weights shown in Figure 3C. If edge points are at the points of index 2 and 6 of Figure 3A, the weights of the edge points and its outer neighbouring point, i.e., the point of index 3, are set to "0". Similarly, If edge points are at the points 6 and 8, 4 and 8, or 2 and 4 of Figure 3A, the weights of the edge points and the outer

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neighbouring points are set to "0". Afterwards, the image data passed through the signal adaptive filtering process are output by the average filter 154 or the weighted filter 156 (step 490).

From the image data filtered as above, a macroblock of 16×16 size is composed again. All the macroblocks in a frame is filtered in such a manner. Here, the size of the blocks filtered by the filtering unit 150 is not limited to the above embodiment of the present invention.

According to the present invention, the blocking effect and ringing noise are removed from a block-based processed image. Thus, the peak-to-peak signal-to-noise ratio (PSNR) and the quality of the decompressed image are enhanced.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly

stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A signal adaptive filtering method for reducing a blocking effect and ringing noise of an image data, comprising the steps of:

(a) calculating a gradient of the image data at each pixel of the image data;

(b) comparing the gradient data of each pixel with a global threshold value (T_g) determined based on a predetermined quantization step (Q) to generate a global edge map information of the pixel;

(c) comparing the gradient data of each pixel with a local threshold value (T_n) which is determined for each block having a predetermined size to generate a local edge map information of the pixel;

(d) performing an OR operation on the global edge map information generated in said step (b) and the local edge map information generated in said step (c), to generate binary edge map information;

(e) applying a filter window of a predetermined size to determine whether edges are present in the filter window based on the binary edge map information within the filter window;

(f) filtering the pixel values of the corresponding filter window pixel by pixel by using predetermined first weighted values to generate a new pixel value if it is determined in said step (e) that edges are not present; and

(g) filtering the pixel values of the corresponding filter window pixel by pixel by using predetermined second weighted values to generate a new pixel value if it is determined in said step (e) that edges are present, wherein the filtering is not performed if the pixel located at the center of the filter window represents an edge.

2. A signal adaptive filtering method as claimed in claim 1, wherein the global threshold value (Tg) in said step (b) is determined by:

$$T_g = \begin{cases} 4Q + 60\,, & 6 \le Q \le 18 \\ 84\,, & Q \le 5 \\ 132\,, & Q \ge 19. \end{cases}$$

where Q is the quantization step of a quantizer.

3. A signal adaptive filtering method as claimed in claim 2, wherein the n-th local threshold value (Tn) in said step (c) is calculated by;

$$T_n = \left| 1 - \frac{\sigma_n}{m_n} \right| * T_g$$

where,

$$\sigma_n = \sqrt{\frac{1}{N} \sum_{(i,j)\in R_n} \{g(i,j) - m_n\}^2}$$

$$m_n = \frac{1}{N} \sum_{(i,j)\in R_n} g(i,j)$$

and g(i,j) represents a gradient image, R_n represents the n-th 8×8 block, m_n and σ_n denote the average and standard deviation, respectively, of the gradient operated values of the pixels of the n-th 8×8 block, and T_g denotes a global threshold value.

4. A signal adaptive filtering method as claimed in claim 3, wherein in said step(c), the gradient data of each of 6×6 pixels which results from excluding boundary pixels from an 8×8 size block, are compared with the local threshold value to generate the local edge map information.

5. A signal adaptive filtering method as claimed in claim 4, wherein the weighted value applied to the pixel located at the center of the 3×3 filter window is equal to 2 in said step (g).

6. A signal adaptive filtering method as claimed in claim 1 or claim 2, wherein the filter window is 3×3 in size.

7. A signal adaptive filtering method as claimed in claim 6, wherein the predetermined first weighted values are equal to 1 in said step (f).

8. A signal adaptive filter comprising:

an image storing unit for temporarily storing decompressed image data;

a gradient operation unit for receiving the image data from said image storing unit in block units of a predetermined size and calculating a gradient of the image data in the horizontal and vertical directions by using gradient operators to find edge pixels;

a global edge map generator for comparing the gradient data of each pixel output by said gradient operation unit with a global threshold value (T_g) determined based on a quantization step (Q) to generate binary global edge map information;

a local edge map generator for comparing the gradient data pixel by pixel, output by said gradient operation unit, with a local threshold value which is individually determined for each block of a predetermined size, to generate binary local edge map information;

an OR-gate for OR-operating, pixel by pixel, the global edge map information from the global edge map generator and the local edge map information from the local edge map generator to generate binary edge map information;

a filter selector for storing the binary edge map information output by said OR-gate and classifying the

input image data into an edge area including information of at least one edge and a homogeneous areas without information of any edges, according to the binary edge map information;

an average filter for performing an average filtering on a central pixel within a filtering window of a filtering area, the filtering area being classified as a homogeneous area by the filter selector, to generate a new pixel value; and

a weighted filter for performing a weighted filtering on the central pixel within a filtering window of a filtering area, the filtering area being classified as an edge area by the filter selector, to generate a new pixel value.

9. A signal adaptive filter as claimed in claim 8, wherein the global threshold value (Tg) is determined in said global edge map generator by:

$$T_g = \begin{cases} 4Q+60, & 6 \le Q \le 18 \\ 84, & Q \le 5 \\ 132, & Q \ge 19. \end{cases} \quad \cdots(3)$$

where Q is the quantization step of a quantizer.

10. A method substantially as hereinbefore described with reference to the accompanying drawings.

11. An apparatus substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9722264.0
Claims searched: 1 to 11

Examiner: John Donaldson
Date of search: 18 February 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4F(FGXA, FGXB, FGXD, FGXX, FHD, FHHX)

Int Cl (Ed.6): H04N 5/00, 5/14, 5/21, 5/213

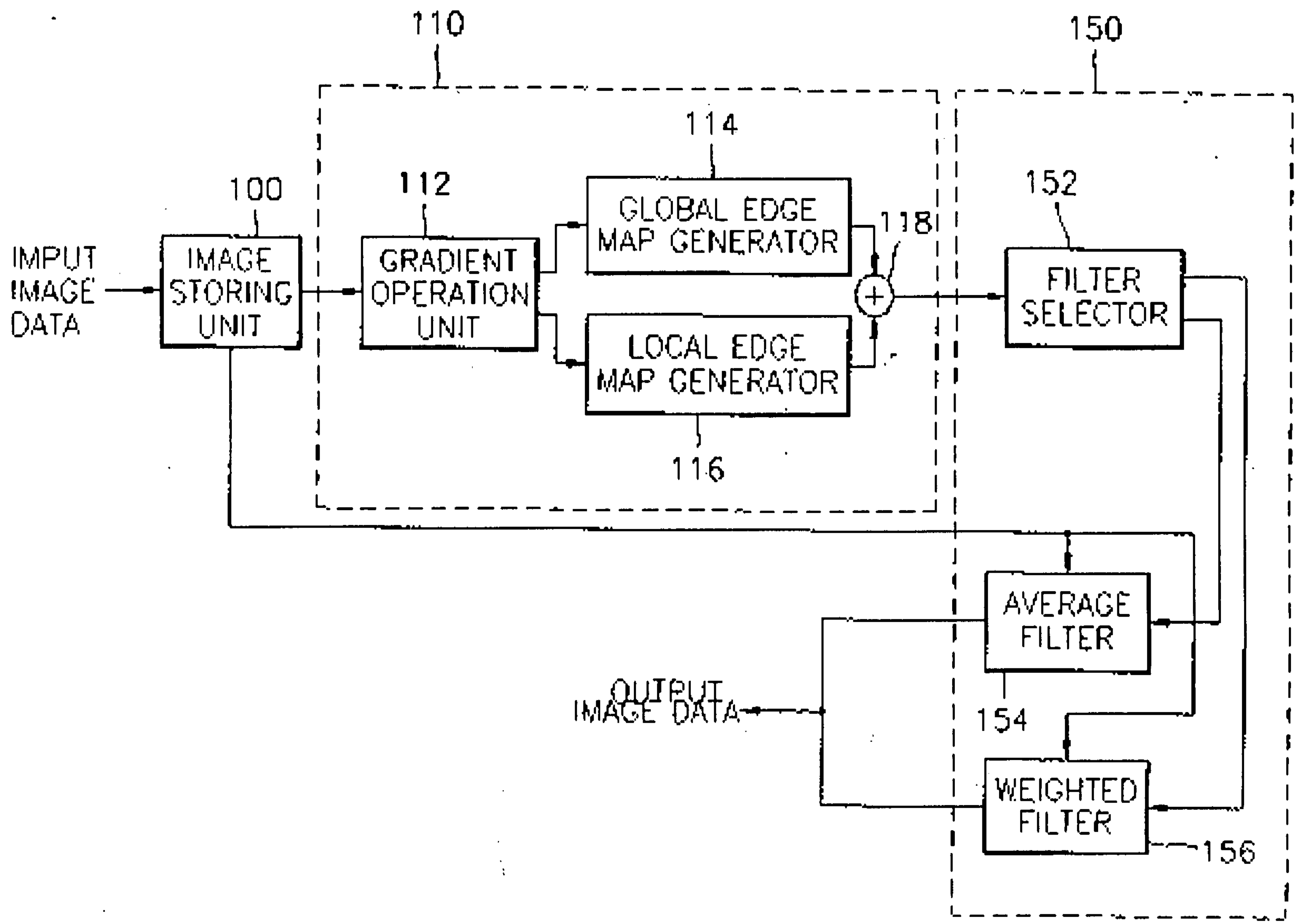
Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	EP 0769878 A2 (MATSUSHITA), see abstract	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		

FIG. 1


110
150
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IMPUT IMAGE DATA
IMAGE STORING UNIT
GRADIENT OPERATION UNIT
GLOBAL EDGE MAP GENERATOR
118
FILTER SELECTOR
LOCAL EDGE MAP GENERATOR
116
AVERAGE FILTER
OUTPUT IMAGE DATA
154
WEIGHTED FILTER
156

FIG. 2

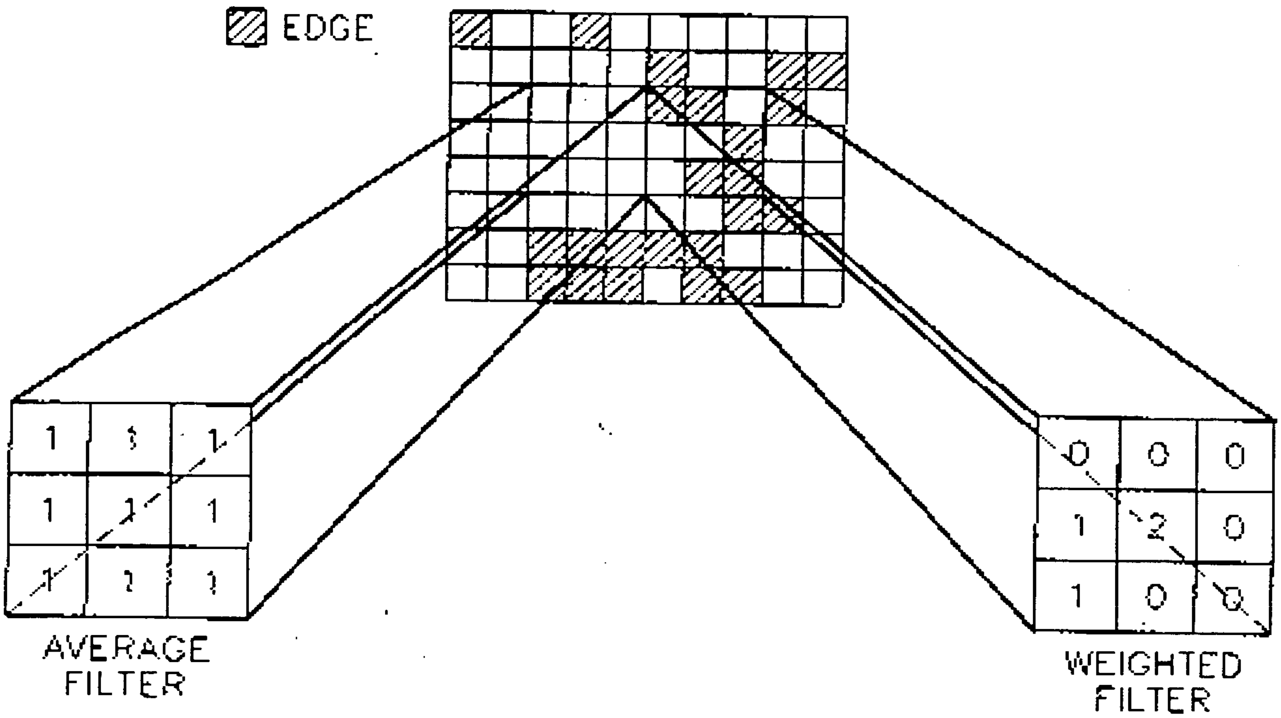


FIG. 3A

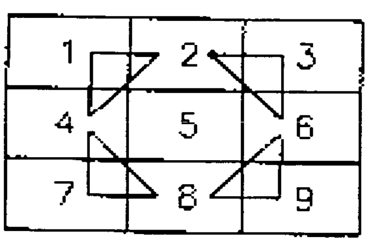


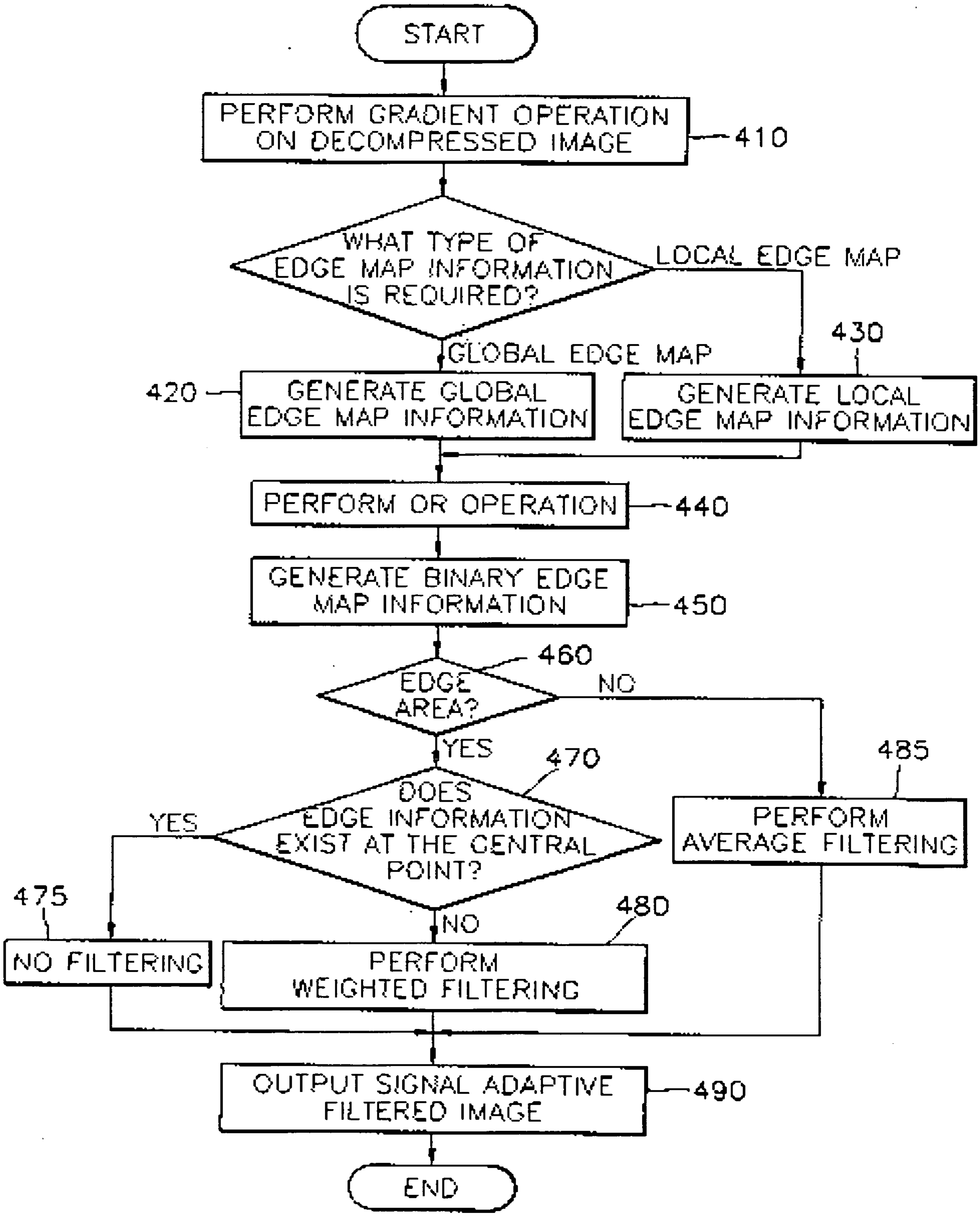
FIG. 3B

1	1	1
1	1	1
1	1	1

FIG. 3C

1	1	1
1	2	1
1	1	1

FIG. 4


START
PERFORM GRADIENT OPERATION ON DECOMPRESSED IMAGE
410
WHAT TYPE OF EDGE MAP INFORMATION IS REQUIRED?
LOCAL EDGE MAP
GLOBAL EDGE MAP
420
GENERATE GLOBAL EDGE MAP INFORMATION
430
GENERATE LOCAL EDGE MAP INFORMATION
PERFORM OR OPERATION
440
GENERATE BINARY EDGE MAP INFORMATION
450
460
EDGE AREA?
NO
YES
470
DOES EDGE INFORMATION EXIST AT THE CENTRAL POINT?
YES
485
PERFORM AVERAGE FILTERING
475
NO
480
NO FILTERING
PERFORM WEIGHTED FILTERING
OUTPUT SIGNAL ADAPTIVE FILTERED IMAGE
490
END